Layout and yaw optimisation of an offshore wind farm

Objective

Wind energy has a very high potential for improvement, especially with regard to wake effects of the turbines within large wind farms. This work focuses the emphasis on potential of aerodynamically optimized wind park layouts and wake steering through yaw angle control.

Methodology

First, a computational tool for analytical modeling of flow conditions between offshore wind turbines is presented. Based on a wake model proposed by Qian & Ishihara, flow velocities as well as turbulence intensities are predicted when several wake flows are superimposed. Subsequently the aerodynamic performance of the wind turbines is calculated. Using the presented tool, the influences of performance-driving parameters such as axial and radial turbine spacing and ambient turbulence are investigated.

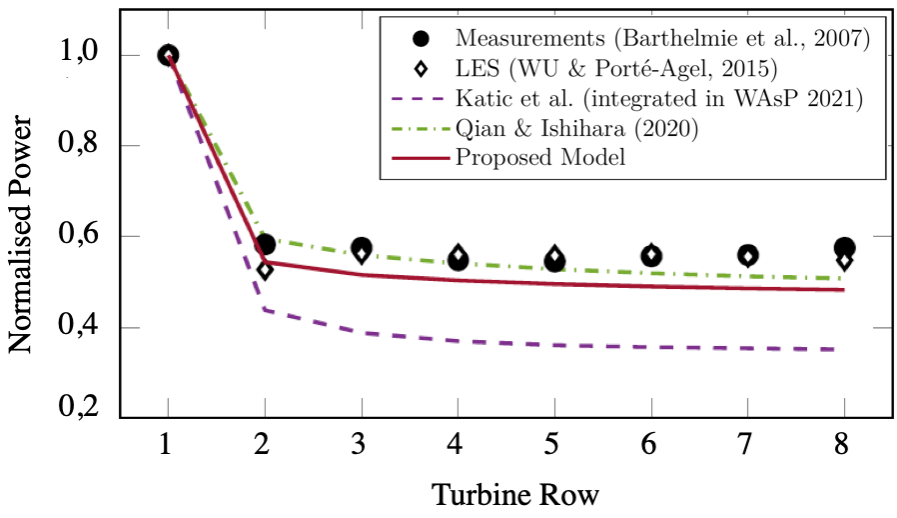

Fig. 1: Power curve for one row of the Horns Rev 1 wind farm normalised to the first turbine.

Results

Following the parameter study the axial turbine spacing and ambient turbulence intensity are identified as the most significant factors. Based on these results, suggestions for an optimized turbine positioning with an aerodynamic power yield of up to 57% at different wind directions of the benchmark wind farm Horns Rev 1 are developed. Furthermore, a yaw angle setting for one none design wind direction is optimized leading to a power gain of approximate 6%. Further work will extend the wind farm optimization tool to include a greater variety of boundary conditions. Moreover, global optimization algorithms including Kriging surrogate modelling will be tested.

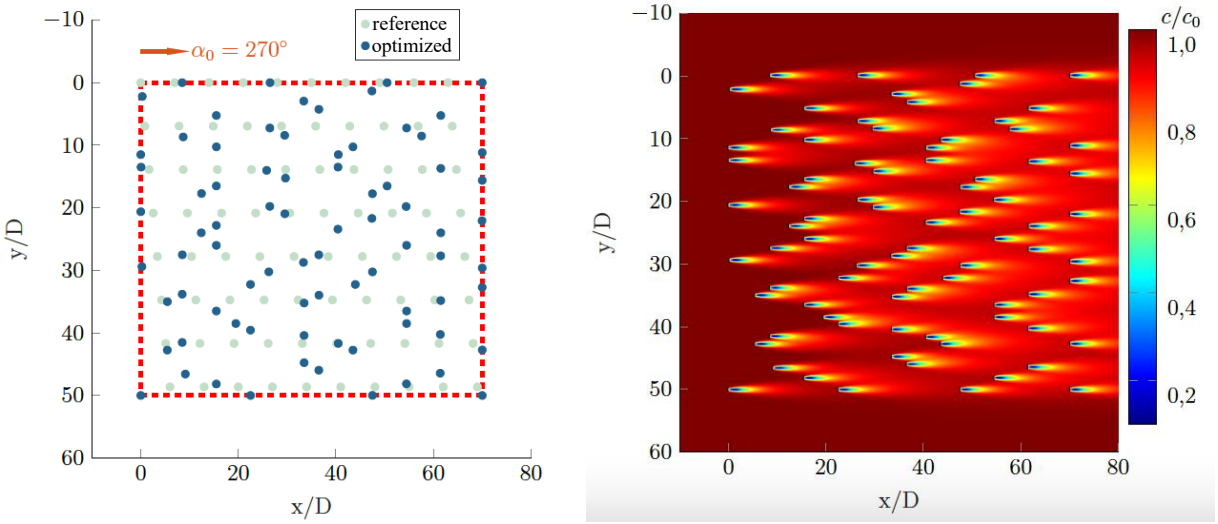

Fig. 2: Proposed optimised wind farm layout. Reference: Horns Rev 1. Left: Schematic illustration. Right: Velocity distribution.

References

Ishihara, T. & Qian, G.-W.: “A new Gaussian-based analytical wake model for wind turbines considering ambient turbulence intensities and thrust coefficient effects”. In: Journal of Wind Engineering and Industrial Aerodynamics 177 (2018), p. 275–292. issn: 01676105. doi: 10.1016/j.jweia.2018.04.010.

Qian, G.-W. & Ishihara: ”Wind farm power maximization through wake steering with a new multiple wake model for prediction of turbulence intensity”. In: Energy 220 (2020), p. 119680. issn: 03605442. doi: 10.1016/j.energy.2020.119680.